The Ideal Hub for a Maize Geneticist

How Do Plants Generate and Continue Making New Organs throughout Their Life Cycle?

MICHAEL J. SCANLON, PLANT BIOLOGY

Shoot Meristems' Amazing Ability

I study plant development—specifically the way plants make shoot meristems and how meristems make organs. A shoot meristem is a ball of organogenic cells, a tiny mass at the tip of the plant shoot, that is responsible for all of the above-ground development of the plant—leaves, flowers, everything above ground. In maize, one of the larger shoot meristems that researchers study, the mass is about the size of the ball tip on a ballpoint pen.

Unlike animals, plants continue to make new organs throughout their life cycle. This ability to remain embryogenic throughout its life cycle is due to meristems. Meristems do two things: they generate new, diverse organs, and they maintain themselves—an amazing ability. We focus specifically on trying to figure out how these two fundamental processes work. It is very complex. This is like a stem cell population in plants. We use classical genetics (mutations) and genomic approaches to look at global gene expression—and hopefully in the near future, protein accumulation in the meristem.

Clarifying Stem Cells in Plants

Although some researchers in plant development do not like to use the term "stem cell" when referring to plants, the practice has become popular. Some properties of animal stem cells and meristem stem cells are the same. Both are developmentally naive and are able to differentiate into all the various cell types found in the mature plant. In this sense, the terminology fits. The meristem, formed in the embryo, is anything that has expansive growth. The meristmatic region at the base of a stem causes expansive growth at the stem, for example. This is meristmatic growth—expansive growth—but it is not generating new organs. It is the shoot meristem that is responsible for generating new organs. The shoot meristem is a special type of meristem that contains what we think of as stem cells, because it is able to differentiate into all kinds of organs of the shoot.

Explaining Genetic Memory

How can we map out the steps from an undifferentiated zygote, a single cell, to a beautifully differentiated and functioning mature plant? How do we understand all the interactions: external and internal, environmental and genetic, and signaling inside of cells? We can describe what happens during the steps, but even getting to that was not trivial. We still do not understand some forms and their variations or how they develop. This is the right time to explore the mechanisms underlying how this all happens and even more exciting, how plants can package the information into

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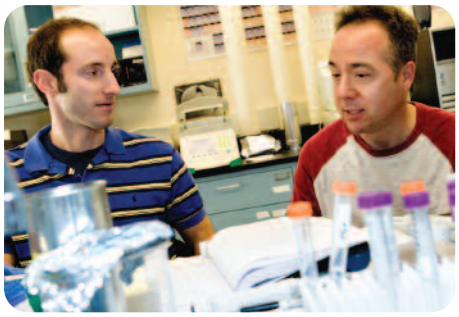

Fascinating!

- Meristems do two things: they generate new, diverse organs, and they maintain themselves—an amazing ability.
- How do these cells, the single zygotes, remember what to do in the next generation? This genetic memory is fascinating—it is how the whole genome interacts with itself and with the environment.
- Once we have this knowledge, we have the tools for influencing major changes that can be useful to humankind—make more food, better fruit, or plants that are more resistant to diseases.... Most of the products we consume are plants—fruits, leaves, and stems, as in sugar cane. These come from shoot meristems. Biofuels are another potential application.
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a tiny seed that has everything ready to happen again. How do these cells, the single zygotes, remember what to do in the next generation? This genetic memory is fascinating—it is how the whole genome interacts with itself and with the environment. This is what we, all plant developmental biologists, would love to discover! It probably will not happen in my lifetime, but I want to make a contribution to getting there.

Fascinated by a Clump of Cells

I started working on maize kernel development as a graduate student. When I went to a postdoc position, I worked on leaf development—how leaves are made from meristems. You can peel off all the leaves of a young seedling, about 14 to 16 leaves (you can see it under a microscope), and get a tiny mass of cells. It is fascinating that this little clump of unimpressive-looking cells can generate a fine differentiated structure. Going from that undifferentiated state to a differentiated state is what captured my attention—the process of development.

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Using the Knowledge of Basic Research

Once we have this knowledge, we have the tools for influencing major changes that can be useful to humankind—to make more food, better fruit, or plants that are more resistant to diseases. Because this is basic research, it has widespread applications. Consider this: most of the products we consume are plants—fruits, leaves, and stems, as in sugar cane. These come from shoot meristems. Biofuels are another potential application. The perfect model biofuel organism is one that perpetuates itself vegetatively (not by fruits), makes lots of biomass (such as branches, but not lots of flowers, because flowers are energy-expensive), and packs all of that energy into the organs. And these plants do not need to be planted every year. Shoot meristems control most of this activity—the switch from vegetation to reproductive growth, degrees of branching, and formation of all the organs.

Once we understand how everything works, can we make these research dreams possible? Possibly, but we have to follow the rules. Part of basic research is learning the rules. We can introduce different variations and put them in certain situations to generate different outcomes. I would like to see this knowledge used, however, to help feed the world—to help people grow crops in situations where they cannot grow them now. This is the applied side of my basic research, to be placed in the hands of applied scientists.

Plants are a convenient tool for studying development. Working with them has many advantages. We can do genetics without many of the moral or ethical underpinnings that come with research on animals. When transferring research knowledge from plants to animals, the conceptual strategies of going from undifferentiated to differentiated tissues are more or less retained, but the homology stops abruptly when we look at the genes that control it.

Why Academia?

Two advantages of working in academia are freedom to work on what I want and the constant opportunity to interact, help, and influence young people. I enjoy teaching in the lab and in the classroom. I can usually see when one person gets it. It is truly satisfying to see a student get excited about science or whatever I am talking about. And it is gratifying to see students move on. I look forward to graduating my first Cornell student.

Biology at the Cinema

I would like to start several new courses for nonscience majors. First, I have to get them into the science classroom. Once they are in there, they can realize that science, even plant science, is a lot more interesting

Scanlon at the lab with (l. to r.)Ryan Douglas, Josh Strable, Beth Takacs, Rena Shimizu, John Woodward, and Katie Petsch

The National Science Foundation just renewed our grant for **$5.2 million** for four years to continue our work on the developmental genomics of the **shoot apical meristem**. It is a collaboration between our group and five other laboratories begun in September 2008.

than they ever thought. An example of such a course deals with how biology is treated and discussed in the cinema. Before the students watch a movie selected for its biological content, we talk about the biology in class—the actual real-life science mentioned, discussed, or spoofed in the movie. We then watch the movie outside of class and discuss certain topics in class: Is it realistic? What are the ethical considerations? For example, who owns the rights to someone's DNA sequence: the government, the insurance company, or the person? The idea is to get people thinking. When they see something on the news or in the movies, they can discern if it is ridiculous or if the idea has potential. Hopefully, they can better understand the science behind some of the critical biological issues that may come up in their lives and make informed decisions.

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Favorite Spots on Campus

The arts quad has magnificent views. I love the suspension bridge. One of my favorite things to do when riding home is to go toward Forest Home and look down into the spot where Barbara McClintock's old cornfield was. This is where McClintock did a lot of her Nobel Prize–winning work. The old field shed where the Emerson research team conducted its corn work is there. There's an amazing photo we maize geneticists know well, and they are all in it: Rollins Emerson, for whom my building is named, and two Nobel laureates who worked on corn, including Barbara McClintock. They are standing in front of the shed in the cornfield. The famous photograph is in the book *Maize for Biological Research*.

When I visited Cornell prior to becoming a member of the faculty, Steve Kresovich (Vice Provost for Life Sciences) knew that as a corn person, I would want to go down there. So we trekked down the hill through the snow—it was February—to the McClintock shed. This is my favorite spot. It is in part of the Cornell Plantations, which is beautiful.

Living in Ithaca

Out of the Lab. I grew up in the northeast, but it was not as extravagantly beautiful as Ithaca is. I lived in Berkeley for almost five years, and then I went to Georgia for eight years. Since I had not lived in winters for 15 years, I was worried about how I would deal with them in Ithaca. But the winters have been terrific. They are beautiful. The summers are fantastic! I ride my bike to work all summer long, and I look forward to doing numerous projects around my house, like keeping the old barn from falling down. When I am not in the lab or classroom, this is what I do—I have enough projects to last for the next 20 years. This is my hobby, but I am also an amateur guitarist—I play blues and folk. I like to read histories; I like to travel; and I have four pets that keep me busy.

Celebrating Winter in Ithaca. This place, Cornell and Ithaca, is fantastic—working hard to bring many activities to the area and to create new things to do, especially in winter. Cornell and Ithaca do much to overcome the feeling of "We're kind of stuck out here." In winter we have the weekend-long Light in Winter event, which is fabulous! And having the Chili Kick-off in the middle of winter when everybody is freezing is a wonderful thrill. You can suffer through winter or you can celebrate it. This town spends its energy to celebrate winter rather than contemplating how long winter may be.

Ithaca's Wonder. Any week or weekend, we can go to lectures, presentations, and museums on the Cornell campus, the Ithaca College campus, or the Sciencenter, or do so many other things. It's unbelievable how much happens here. We can pick up *Ticket*, the events magazine in the *Ithaca Journal*, the *Ithaca Times*, or the *Cornell Chronicle* and read about a multitude of events. Plus, we have three excellent arts theaters.

Just a Train. Not long ago, a researcher visited from Germany, and he said to me en route, "I'll be in New York, so I'll plan on taking the train to Ithaca." I said, "That would be great, but, we don't have a train!" He replied, "I'm European. I just figured there would be a train." The airport is good, but I will wish for one more thing in Ithaca. A train. I want an Ithaca–New York City train. I love to go to New York City, for example, to see a ballgame.

The Last Word

From Past into Future

Cornell has a famous past, but more important is what is available here, now and in the future. Cornell has a wonderful legacy and a fantastic future—such great potential.

For more information:

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About Scanlon

Years as Cornell faculty
2.5

Came to Cornell from
University of Georgia at Athens

Favorite spot on campus
McClintock shed at the Cornell Plantations

Cornell's research distinction
Innovation

Cornell's trademark
A legacy of inclusiveness—a founding principle of nondenominational religious preference and admission of women and people of any race

I am also
A folk/blues guitarist